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ABSTRACT

Three procedures of the free-sort methodology which are usually standardized were varied in an attempt to discover the effects of such variation upon the number and nature of manifest categorizations. The conditions investigated were effectiveness of the sorting cue, the effects of the order of stimulus presentation and the effect of re-sorting. An explicit sorting cue was shown to be a highly significant determinant of the number of manifest categorizations, but not of the quality or nature of these categorizations when compared with an implicit (instructional) sorting cue. The effects of differing explicit sorting cues should be the object of further study. The effects of stimulus ordering were not significant as anticipated, although the treatment means were in the predicted order. Subjects encountering initial stimuli which were very homogeneous formed more manifest categories (means=7.88) than did subjects sorting decks with initial-heterogeneous (mean=6.45) or completely randomized (mean=6.76) stimuli. Subjects encouraged to re-sort their manifest categorizations formed categories which were significantly different in nature, but not in number, from the categorizaticns of subjects who were not encouraged to re-sort. In addition, there was a significant interaction effect between re-sorting and type of sorting cue. (Author)

THE EFFECTS OF PROCEDURAL VARIATION IN FREE-SORTING EXPERIMENTATION[1]

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Categorization methodology was developed during the mid-1960's as a unique procedure for generating and analyzing qualitative information. This procedure evolved out of an empirical study of teachers' views regarding the facilitation of learning. The study required a methodology which would "manifest and explicate teachers' views" by the discrimination of similarities and differences between selected content units. Thus, each teacher was

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required to categorize these content units on the basis of "his own perceptions and cognitions regarding the facilitation of learning." This would result in a set of categories for each teacher. The problem is then one of identifying the underlying commonalities of these individual sorts (Miller et al., 1967, p. 98).

The four stages of the methodology include:

I Observing and collecting substantive, qualitative data.

II Summarizing and organizing the elements of the data.

III Manifesting and explicating the substance and structure of the data.

IV Identifying the latent structure of the substantive manifestations (Ibid., p. 175).

A procedure was needed which would allow each teacher (sorter) to encounter a content unit, perceive its primary concept, and to categorize it in relationship to preceding content units (stage III). This necessitated a manipulative task with enough freedom to allow the sorter to apply his own substantive meanings.

Several methods of categorizing content units were tested. One method first divided the content units into two gross categorizations and then subdivided these categorizations into specific categorizations. This method was found to be extremely time consuming and psychologically unsatisfactory, since the content units must be manipulated once for each hierarchial level of gross and specific categorization. An alternative method would necessitate *a priori* sorter specification of a taxonomy of his views of facilitating learning. However, prior category definition may bias sorting results since content units might be considered only within their fit to the established

taxonomy rather than on independent sorter perception of the content unit itself.

The sorting method selected consists of the following major steps:

1. Read and think about the first content unit.

2. Decide with what aspect of facilitating learning this content unit is concerned.

3. Write down a tentative statement of that aspect of learning.

4. Place the content unit in a pocket to begin a category or group.

5. Take the next content unit and perform steps 1 and 2. If the second unit concerns the same aspect of facilitating learning as the first, group together the two units. If the second unit concerns a different aspect of learning, perform steps 3 and 4.

6. Repeat steps 1 through 5 for each content unit (Ibid., p. 99).

Pilot testing indicated the need for three additional steps:

7. Re-sort at any time during steps 1 to 6 when a unit is encountered which does not belong where it was previously placed. The re-sort may involve:

   a. placing a unit in another group,

   b. starting a new group, or

   c. mixing it with the units not yet sorted.

8. Review the groups carefully after completion of steps 1 to 6. Review the ideas of each grouping with special concern for whether the units belong together. Changes may be made by dividing, combining, or switching the statements. If in doubt, begin a new category.

9. Check after sorting all units to see that a word or short phrase has been written (on each category index card) which gives the central idea explaining why the units were grouped (Ibid., p. 100).

No directions were given to the sorter as to the number of categories they could form, or the number of content units which could be placed within a given category. The sorter was free to establish and define his own categorizations. Thus, this method has become known as the free-sorting, or F-sort, techniques (Miller et al., 1969).

The data obtained from the F-sort is then analyzed in stage IV by any one of several available procedures (see Haenn, 1971). Most of these analyses have been based on the model of Latent Partition Analysis (LPA) developed by Wiley (1967) and computer programmed by Wolfe (1967). (For an excellent discussion of LPA and a review of related procedures, see Gross, 1970.)

A typical F-sort consists of the following parts. There is a presentation, and numerous reminders, of a sorting cue during the task instruction period. The sorters are then allowed an unlimited amount of time to sort the randomly-ordered, but homogeneous, stimuli (content units) into categories of their own choosing. The subjects are allowed to re-sort the stimuli as often as they wish, and are sometimes asked to title their manifested categories, but there is no external pacing. The function of the sorting cue, the homogeneity of the stimuli, and the re-sorting components are the subject of study in the present report. Other variables, such as number of stimuli (content units), time allowed for administration, number of sorters, and the like, will be left for other investigators.

Sorting cue. The directions for the sorting procedure which are administered prior to the actual sorting period will contain some implicit, operational discrimination criterion to the sorter, such as "sort those stimuli together which you feel should be together." However, the typical experiment also contains an explicit substantive criterion, such as "form groups indicating your ideas as to the kinds of things a teacher does with respect to facilitating learning of elementary/secondary school students" (Miller et al., 1969, p. 43). This latter type of discrimination criterion,

known as a sorting cue, sets a definite standard for sorting (here, it is for sorting according to stimulus similarity pertaining to the facilitation of learning), while the former type of sorting cue is instructional, but allows the sorter to set his own criterion. Such cues fit a type d instruction, one that provides information of a substantive type, such as a sorting principle (Klausmeier and Meinke, 1968).

Homogeneity of stimuli. Stimuli are usually randomly punched and printed on IBM cards for ease of analysis through a computer procedure. Thus, each deck of stimuli is prepared in such a way that every sorter has an equal probability of being presented each possible stimulus ordering. This has been done to eliminate the effects of stimulus ordering and stimulus perseveration on the categorization procedure.

Re-sorting. After each stimulus has been encountered and categorized, subjects are encouraged to re-sort their categorizations. Such re-sorting is expected to provide a check on the homogeneity of each categorization. This is consistent with the design of the sorting procedure to promote the evolution and induction of categories, rather than deduction.

Statement of the Problem

The recency of the development of categorization methodology has precluded any extensive research into the effects of variation in normal administration procedures. This is especially true of the F-sort technique, which has developed a standardized set procedures for administration. Effects of elimination or variation in the sorting cue,

homogeneity of initially-encountered stimuli and absence of re-sorting may have profound effects on the outcomes of free-sorts. Variations in these conditions will form the hypotheses of the study.

Hypotheses

1. There will be no differences on measures of sorting behavior between subjects receiving an explicit, substantive sorting cue and subjects receiving an implicit, operational sorting cue.

Verbal instructions about task procedures or solution cues have been found to have a facilitating effect on performance during problem-solving learning (Wittrock et al., 1964), especially if used in a repetitive or confirmatory manner (Wakai, 1967). Knowledge of a principle or cue also facilitates performance better than knowledge of problem structure (Klausmeier and Meinke, 1968). However, arousal reduces effective utilization of cues (Easterbrook, 1959).

Haenn (1968) found no differences between utilization of task instructions and instructions containing a solution cue in a learning set formation study with preschool children. Children required to categorize objects on their own did as well or better than children given extensive cues, although their categorizations were more relational and utilized more obvious, sensed stimulus characteristics than the more analytical categorizations of children receiving cues (Edwards, 1969). In both studies, instructed subjects performed better than their control counterparts.

These contradictory results give little evidence pertaining to the present investigation. It is hypothesized that sorting differences

on this given stimulus sample will be due to inherent characteristcs of the stimuli themselves and, therefore, an explicit sorting cue of this type will do little to intensify these characteristic differences.

If the data fail to confirm this hypothesis, the effect of stronger and differential sorting cues should then be tested in later experimentation.

2. The homogeneity of initially-encountered stimuli will result in different numbers and types of manifest categorizations.

In their original study, Miller et al. (1967) stated:

> . . . presentation of the units (stimuli) according to their consecutive numbering was likely to influence a sorter's construction of categories. As this ordering effect could not be studied in detail, the possibility of its occurrence was counter-balanced by randomization of content units (stimuli) This randomization minimized any artifacts due to primacy or recency effects (p. 104).

Also, they stated elsewhere:

> . . . there are certainly differences between the information processing of the first item and of succeeding items. The experimental procedure attempted to skirt such questions by randomizing the order of the content unit stimuli (p. 111).

Since the nature of stimuli provides a major cue concerning the expected range of the judgment scale (Upshaw, 1970), stimuli presented early in the deck will probably have a greater effect on the total range within which later stimuli will be sorted. This adjustment of the scale of judgment to stimuli is known by many names, but Johnson and Mullally (1969) suggest the term "context effect," as each stimulus is judged in the context of already sorted stimuli. Upshaw (1970) believes that most people are aware of context effects at an early age.

The range of stimuli should also determine the size of the sorter's judgmental unit (Upshaw, 1970), especially when there is a finite

population of stimuli to be sorted. Upshaw (1970) states:

> . . . when judging with a relatively large unit (heterogeneous) item), a subject sets his perspective at a position which is more extreme in either direction (has a higher probability of being placed into a distinct category) than is the case when he judges with a relatively small unit (p. 133).

Conry (1970) has been conducting exploratory research on the "mix of item characteristics" (homogeneity of the sorting stimuli) and the type of sorting item (snow crystals or verbs). He has discovered an interaction effect between the mix and item sorting type, suggesting that not only stimulus presentation itself, but also the type of stimulus influences the sorting procedure. (For a review of the types of stimuli thus far explored, see Haenn, 1971.)

The free-sorting outcomes are summarizations of all manifest sorts (called S matrices) which represent the proportion of sorters who categorize each pair of stimuli together in the same manifest category. These S matrices then become the input for Wiley's (1967) Latent Partition Analysis, or LPA.

It has been demonstrated that just a simple variation in one of these standardized sorting procedures (presenting initially-homogeneous or initially-heterogeneous stimuli) can greatly affect the average number of manifest categories sorted by each group (Haenn, 1971). Since an S matrix is based on joint proportions and the total item set is fixed, fluctuations in the average number of manifest categories will be reflected throughout the LPA procedure.

Thus, the beginning stimuli encountered by a sorter delimit the range of later categorizations. If the initially-encountered stimuli are very homogeneous, sorters should tend to make finer discriminations and, on the average, form more manifest categories. Subjects encountering

initially-heterogeneous stimuli should make more gross discriminations and form manifest categorizations of a type more closely aligned with the latent categories previously determined by statistical procedures of other sorts. Subjects receiving completely-randomized decks should form manifest categorizations somewhere between these extremes.

> 3. The re-sorting procedure affects the type, but does not affect the number of final manifest categorizations.

Re-sorting was added after some initial pilot testing in the Miller et al. (1967) study ". . . to provide an opportunity for sorters to review the composition of their categories . . . (p. 105)." Its function was ". . . to ensure that content units (stimuli) were homogeneously grouped and not necessarily to provide opportunity for extensive restructuring or redefinition of categories (p. 106)."

Re-sorting should tend to eliminate a chaining effect, whereby the last stimulus sorted into a category is only remotely related to the first stimulus of that category. Several excellent studies have been conducted which explored the relationship between free-sorting, associational and chaining procedures (Johnson, Ashton, Deken, and Robb, 1970; Johnson et al., 1970b). However, the effects of re-sorting on the quality of conceptual categorizing have not yet been examined.

Re-sorting usually occurs after all stimuli have been encountered. Since it is hypothesized that intially-encountered stimuli delimit the range of categorization, the function of re-sorting should be primarily to tighten this structure by relegating ambiguous stimuli to more relevant manifest categories. Subjects who re-sort their manifest categories should then have final manifest categorizations which are more similar to the underlying latent structure.

METHOD

Subjects

The subjects of this study were twelfth-grade, male students drawn from two 1500-student senior high schools located within the same school district. This school district encompasses predominantly white, middle class communities of approximately 60,000 residents in the suburbs of a large midwestern city.

These high school subjects have everyday exposure to teachers who are attempting to facilitate learning in the classroom. Their twelve years of schooling experience should make them aptly suited for the stimuli to be utilized in the free-sort procedure. The results of their sorts could be compared with the already obtained results from teacher trainees and experienced elementary and secondary school teachers.

The subjects were selected from senior physical education classes. One hundred twenty-five subjects completed all phases of testing. They ranged in age from 17-2 to 19-9 years of age, with a mean of 18-0.8 years and a standard deviation of 5.507 months.

Variables

Five variables were investigated in the study. One of these variables was intended to be intelligence. However, intelligence measures were not available within this school district and a performance measure was chosen instead. Performance and age comprise the independent variables and three measures of sorting behavi-r were used as the dependent variables.

Sorting stimuli. The F-sort was completed by each subject utilizing a refinement of the fifty teacher verbs used in later portions of the Wisconsin study (Miller et al., 1967). The earlier sorting stimuli for the Wisconsin study had been classroom content units. These were in the form of sentences describing teacher behaviors. However, the nature and number of stimuli required very long sorting times and necessitated quite small sample sizes.

The problem was one of devising a set of content units which were easy to sort but still would be useful in a study of teachers' perceptions of classroom learning. Present tense, third person verbs were selected which described definite classroom actions. After some pretesting, a final set of fifty verbs was selected.

The refinement of the fifty verbs by the present study attempted to further eliminate ambiguities in the latent category structure. The original data from one of the most popularized of the Wisconsin sub-studies--the elementary and secondary teacher study (Miller et al., 1967; 1969)--was secured and analyzed by Latent Partition Analysis (LPA).

Insert Table 1 about here

The Φ matrix in Table 1 gives the verb composition of the latent categories for all 703 sorters based upon a ten-category solution. A dual criterion was established based on evaluation of the loading a verb received within the latent category into which it was placed and the difference between this loading and the highest non-latent category loading. The first measure estimates the relative strength of the item within a given category

Table 1

$\hat{\Phi}$ - 10-CATEGORY SOLUTION TO 50-VERB S-MATRIX

Original Number	Verb	1	2	3	4	5	6	7	8	9	10
11	Demonstrates	101	-2	-2	2	-3	-1	1	1	3	1
21	Illustrates	97	-0	1	1	-4	-0	10	-2	-1	-0
13	Displays	95	-2	2	4	3	-2	-2	-0	3	4
48	Threatens	-1	110	3	-2	2	-1	1	-14	-5	3
29	Penalizes	-1	1-5	5	2	1	-2	4	-5	-10	-1
39	Reprimands	-1	100	4	-2	1	-2	6	4	-8	-2
10	Demands	-3	79	-12	1	-0	4	-9	5	24	10
40	Restricts	3	75	-5	-2	-3	-4	-1	44	-6	-1
22	Impels	-5	73	-1	-1	1	-0	-11	-11	40	16
6	Commends	3	2	110	6	1	14	8	8	-15	-35
23	Inspires	-1	-0	106	-8	1	-16	-18	-12	10	37
15	Encourages	-8	-6	106	-6	-1	-4	-5	-1	14	12
45	Stimulates	3	0	98	-8	-1	-16	-13	-11	6	43
42	Rewards	6	14	95	20	1	18	9	1	-20	-44
20	Grades	3	1	-2	104	1	4	-10	-4	5	-2
47	Tests	3	-2	-2	102	0	10	-13	-3	0	6
17	Evaluates	-0	-6	10	97	1	-13	15	4	-8	0
26	Judges	0	6	-6	90	-2	-8	5	6	9	-1
32	Plans	0	2	8	0	103	-1	1	-5	-8	1
28	Organizes	2	1	2	-2	102	-4	11	-2	-1	-8
3	Arranges	-1	1	-2	-1	98	-2	10	0	3	-6
43	Schedules	-5	-1	-8	3	97	2	-13	7	6	8
38	Repeats	-2	-3	-8	-7	-0	118	14	-6	2	-8
41	Reviews	-3	1	2	5	1	108	2	-13	-13	12
14	Drills	1	3	-15	3	-7	105	-34	-2	6	39
36	Reinforces	4	-1	41	-2	3	89	23	-1	-16	-40
37	Reminds	-2	-4	0	-5	0	72	6	23	36	-24
49	Tutors	2	-17	-1	-4	-4	40	-5	30	10	39
5	Clarifies	2	1	-5	-6	4	6	111	-3	-6	-4
44	Simplifies	8	1	-10	-7	8	12	97	-4	3	-9
24	Interprets	-4	1	-8	10	-0	-15	87	-0	3	27
19	Explains	21	3	-6	-7	-0	-6	76	-0	-6	29
34	Reasons	-14	-0	3	-3	-1	-17	62	2	31	36
7	Confirms	-8	-5	18	9	3	27	57	7	19	-28
18	Exemplifies	39	-2	13	-1	1	-4	44	4	14	-10

NOTE: Each entry is multiplied by 100 for ease in reading.

Table 1 (continued)

Original Number	Verb	1	2	3	4	5	6	7	8	9	10
35	Regulates	-1	0	-12	-0	-2	-6	-2	123	1	-3
8	Controls	6	14	-7	-0	-5	-3	-3	119	-5	-11
46	Supervises	-6	-30	3	3	7	-3	-5	107	-5	29
30	Permits	-3	0	39	-4	-5	-6	12	80	-5	-10
16	Enforces	8	42	3	1	-5	21	5	54	-1	-24
1	Advises	-11	-26	25	-3	-1	-10	17	48	31	26
31	Persuades	4	-2	-1	2	-1	-1	-5	-3	118	-8
9	Convinces	3	-3	-14	3	1	-3	14	-2	107	-6
50	Urges	-4	3	38	-1	-2	2	-14	-6	81	6
12	Discusses	2	3	12	-9	-11	-9	36	3	-18	93
33	Questions	-25	7	13	20	-11	5	25	-6	-18	93
27	Lectures	42	5	-14	-3	-2	20	-35	5	5	77
25	Introduces	34	4	18	-7	19	-0	-19	-5	-11	70
4	Assigns	-5	-4	-13	4	33	29	-37	20	7	67
2	Answers	-22	6	-8	13	-5	21	48	-8	1	57

NOTE: Each entry is multiplied by 100 for ease in reading.

based on the structure, while the second measure estimates the confusion of the item with any other latent category. The number of verbs falling within given cells of a matrix of these criterion is given in Table 2. Based on

Insert Table 2 about here

a dual criterion eliminating all verbs having both a loading less than 0.60 and a non-latent category entry within 0.25 of the latent category loading, the following verbs were eliminated in a series of analyses: (1) advises, (2) answers, (4) assigns, (7) confirms, (12) discusses, (16) enforces, (18) exemplifies, (33) questions, (34) reasons and (49) tutors.

Table 2

50-VERB MATRIX OF CRITERIA FOR A 10-CATEGORY SOLUTION

Highest Latent Category Loading (rows) × Highest Non-Latent Category Loading (columns)

Number of Verbs	w/i .50	w/i .45	w/i .40	w/i .35	w/i .30	w/i .25	w/i .20	w/i .15	w/i .10	w/i .05
Loadings ≤.85	16	15	13	11	7	5	5	4	3	2
Loadings ≤.80	15	14	13	11	7	5	5	4	3	2
Loadings ≤.75	12	12	12	10	7	5	5	4	3	2
Loadings ≤.70	9	9	9	8	7	5	5	4	3	2
Loadings ≤.65	7	7	7	7	7	5	5	4	3	2
Loadings ≤.60	6	6	6	6	6	5	5	4	3	2
Loadings ≤.55	4	4	4	4	4	4	4	3	2	2
Loadings ≤.50	3	3	3	3	3	3	3	2	2	2
Loadings ≤.45	2	2	2	2	2	2	2	2	2	2
Loadings ≤.40	1	1	1	1	1	1	1	1	1	1

An analysis of the resulting 40-item S-matrix produced the Φ matrix given in Table 3. The matrix of criteria (Table 4) shows that this solution is extremely well structured, having no loadings less than .60 and

Insert Tables 3 and 4 about here

no non-latent category entries within 0.25. In fact, the lowest loadings are above .70 with no non-latent category loadings within 0.35. The remaining items, listed in Table 5, were selected as the stimuli for sorting in this study.

Insert Table 5 about here

Measures of Sorting Ability

Three measures of sorting ability were computed for each subject. These are:

1. Number of manifest categories.
2. Prototypic Discordance score.
3. Conceptual Disparity score.

There has been a definite need for obtaining methods of scoring individual categorization behavior "...which accurately reflect quality of conceptual categorization, as well as the number of categories" (Sloane, Gorlow and Jackson, 1963, p. 402). Prototypic Discordance (PD) has been presented as one such method (Miller et al., 1967). It was designed to measure the ". . . extent to which the composition of a sorter's categories differed from the composition of the latent partition (p. 125)." PD is

Table 3

$\hat{\Phi}$ - 9-CATEGORY SOLUTION TO 40-VERB S-MATRIX

Original No.	New No.	Verb	1	2	3	4	5	6	7	8	9
11	7	Demonstrates	110	-1	-0	-1	-7	-2	-2	2	3
13	8	Displays	107	-0	4	1	-1	-3	-4	-0	-6
21	14	Illustrates	105	-0	2	-2	-7	-1	-5	-0	9
27	20	Lectures	85	3	-17	2	5	21	10	4	-16
25	18	Introduces	68	0	13	-1	24	1	-2	-4	2
48	39	Threatens	-0	111	3	-1	1	-1	-7	-10	2
29	22	Penalizes	-1	107	6	2	0	-2	-12	-4	4
39	30	Reprimands	-2	102	6	-2	-0	-1	-10	4	4
10	6	Demands	2	82	-13	2	1	4	24	3	-5
22	15	Impels	1	76	-4	0	3	1	43	-12	-5
40	31	Restricts	4	75	-4	-2	-4	-3	-6	41	-1
6	3	Commends	-8	2	110	2	-3	11	-16	8	-6
42	33	Rewards	-9	15	105	14	-4	15	-32	2	-8
23	16	Inspires	13	-4	98	-5	5	-18	21	-12	1
15	10	Encourages	-3	-8	98	-5	1	-5	21	-2	3
45	36	Stimulates	20	-4	93	-4	3	-20	17	-11	7
20	13	Grades	0	1	-1	103	1	4	2	-3	-8
47	38	Tests	4	-2	-1	101	1	10	0	-3	-9
17	11	Evaluates	-2	-5	10	97	0	-9	-6	3	13
26	19	Judges	-3	7	-5	91	-3	-7	8	5	7
32	25	Plans	1	1	6	0	104	1	-7	-4	-2
28	21	Organizes	-1	0	2	-2	103	-2	-2	-1	6
43	34	Schedules	-2	-0	-8	4	100	3	5	5	-10
3	1	Arranges	-5	1	-1	-1	99	-1	1	2	7
38	29	Repeats	-7	-2	-6	-6	-1	106	2	-2	17
41	32	Reviews	2	-0	1	6	3	104	-9	-10	5
14	9	Drills	20	1	-16	6	-1	101	9	-0	-22
36	27	Reinforces	-10	1	43	-5	-0	80	-17	-1	8
37	28	Reminds	-13	-3	4	-7	-1	69	31	21	0
9	5	Convinces	0	-6	-16	3	-0	-0	107	2	9
31	24	Persuades	-3	-3	2	0	-2	1	106	3	-3
50	40	Urges	-4	2	35	-1	-0	2	79	-5	-7

NOTE: Each entry is multiplied by 100 for ease in reading.

Table 3 (continued)

Original No.	New No.	Verb	1	2	3	4	5	6	7	8	9
35	26	Regulates	-3	-5	-10	-0	1	-4	5	117	1
8	4	Controls	3	14	-4	-1	-5	-1	-3	105	-5
46	37	Supervises	8	-25	5	6	13	3	0	85	4
30	23	Permits	-4	-1	40	-5	-6	-2	-1	72	4
5	2	Clarifies	-6	1	2	-3	-1	6	-3	-0	104
44	35	Simplifies	-9	4	-3	-5	3	7	2	-3	104
24	17	Interprets	3	-2	-4	15	-2	-11	9	3	88
19	12	Explains	31	1	-2	-3	-2	-3	-1	2	78

NOTE: Each entry is multiplied by 100 for ease in reading.

Table 4

40-VERB MATRIX OF CRITERIA FOR A 9-CATEGORY SOLUTION

Highest Latent Category Loading (rows) × Highest Non-Latent Category Loading (columns)

Number of Verbs	w/i .50	w/i .45	w/i .40	w/i .35	w/i .30	w/i .25	w/i .20	w/i .15	w/i .10	w/i .05
Loadings ≤ .85	8	7	5	3	0	0	0	0	0	0
Loadings ≤ .80	8	7	5	3	0	0	0	0	0	0
Loadings ≤ .75	4	4	3	2	0	0	0	0	0	0
Loadings ≤ .70	2	2	1	0	0	0	0	0	0	0
Loadings ≤ .65	0	0	0	0	0	0	0	0	0	0
Loadings ≤ .60	0	0	0	0	0	0	0	0	0	0
Loadings ≤ .55	0	0	0	0	0	0	0	0	0	0
Loadings ≤ .50	0	0	0	0	0	0	0	0	0	0
Loadings ≤ .45	0	0	0	0	0	0	0	0	0	0
Loadings ≤ .40	0	0	0	0	0	0	0	0	0	0

Table 5

LIST OF SELECTED TEACHER VERBS

1	Arranges	21	Organizes
2	Clarifies	22	Penalizes
3	Commends	23	Permits
4	Controls	24	Persuades
5	Convinces	25	Plans
6	Demands	26	Regulates
7	Demonstrates	27	Reinforces
8	Displays	28	Reminds
9	Drills	29	Repeats
10	Encourages	30	Reprimands
11	Evaluates	31	Restricts
12	Explains	32	Reviews
13	Grades	33	Rewards
14	Illustrates	34	Schedules
15	Impels	35	Simplifies
16	Inspires	36	Stimulates
17	Interprets	37	Supervises
18	Introduces	38	Tests
19	Judges	39	Threatens
20	Lectures	40	Urges

computed separately for each subject using both the S-matrix for the total group and the S-matrix for the individual. Prototypic Discordance is defined as the sum of the squares of the element-by-element differences between the total group (or specified sub-group) S-matrix and the individual's S-matrix. In mathematical notation this would be represented as:

$$PD = \sum_{i>j} \sum (_{ij}\text{th element of the S matrix for the total sample} - {}_{ij}\text{th element of the S matrix for a given subject})^2.$$

The S matrix is the symmetric joint proportion matrix indicating the probability that any two items were sorted together. Thus, larger PD weights will be obtained for poorer sorts and indicate a lack of concordance with other sorters.

A second measure has been proposed by the author and is considered as an exploratory measure in this discussion. The Conceptual Disparity (CD) score is also based on the sample population S matrix, but considers the latent category (Φ) matrix in addition.

The equations consist of two stages. In stage one, a standardizing coefficient (CD*) is derived from the S and Φ matrices by:

$$\underset{NS\times NLC}{\Lambda} = \underset{NS\times NS}{S} \cdot \underset{NS\times NLC}{\Phi}$$, where NS = number of stimuli, and NLC = number of latent categories

$$\underset{NS\times NLC}{K} = \underset{NS\times NLC}{\Lambda} \; xx \; \underset{NS\times NLC}{\Phi}$$, a Haddamard multiplication.

$$CD^* = \sum_{i=1}^{NS} \sum_{j=1}^{NLC} K_{ij}$$

In stage two, the Conceptual Disparity (CD) score is computed from the sample joint proportion (S) matrix, the matrix of manifest partitioning for a given subject (Z_i) and the standardizing coefficient (CD*) by

$$\underset{NS \times NMC}{\Lambda} = \underset{NS \times NS}{S} \cdot \underset{NS \times NMC}{Z_i}$$, where NMC = number of manifest categories.

$$\underset{NS \times NMC}{K} = \underset{NS \times NMC}{\Lambda} \text{ xx } \underset{NS \times NMC}{Z_i}$$

$$CD = \tfrac{1}{2} \left(CD^* - \left(\sum_{i=1}^{NS} \sum_{j=1}^{NMC} K_{ij} \right) \right)$$

In each stage, the joint proportion (S) matrix is post-multiplied by either the latent category (Φ) or manifest partition (Z_i) matrix and then this product is Haddamard multiplied (element-by-element multiplication) by these same matrices to produce a matrix K. This K matrix is simply a joint proportion (S) matrix which has been re-scaled by either the latent category (Φ) matrix or the manifest partition (Z_i). The elements of the K matrix are then summed and subtracted from the standardizing coefficient to give CD.

Thus, we arrive at a score which estimates the degree of disparity for a given manifest sort from the underlying latent structure. In addition, the sign of the score may indicate whether the number of manifest categories is greater than, or less than, the number of underlying latent categories.

In a pilot computation four latent categories were assumed as the underlying latent structure for seven stimulus items. For all manifest partitions with at least one more (less) category than the number of latent categories, the computed CD's were positive (negative). It is hoped that an underlying latent structure with more latent categories and based on a larger number of stimulus items will produce even clearer results.

The computational values of CD contain information not only about the type, but also about the number of manifest partitions. This statistic is limited only in the extreme cases where all NS stimuli are sorted into either 1 category or NS categories, for which there is no solution.

Procedure

Age and performance measures were obtained from school records. The performance records consisted of American College Test (ACT) comprehensive scores and Iowa Test of Educational Development (ITED) quantitative thinking, correctness of expression and composite scores. However, not all information was available for all subjects, and for some subjects there was no information at all available. Therefore, the ACT score was selected as the measure of interest. For those subjects who had only ITED scores, a regression analysis was used to determine an appropriate ACT score. For those subjects with no scores, classroom means were used. Means had to be used for less than 13 per cent and regressions for less than 18 per cent of the total classroom populations.

Special instructions were prepared for each class appropriate to one set of treatment conditions. This required the construction of four sets of instructions: explicit sorting cue subjects; explicit sorting cue subjects who were encouraged to re-sort; implicit sorting cue subjects; and, implicit sorting cue subjects who were encouraged to re-sort. Types of initially-encountered stimuli could be randomly varied within each classroom.

Subjects were tested during their regular physical education activity periods. Sorting times varied within each classroom, but all subjects completed the task within one class period and at one sitting.

The design of the study is a complete factorial design with two levels of sorting cue (implicit vs. explicit sorting cue), three types of stimulus presentation (initial-homogeneous, initial-heterogeneous, and completely-randomized stimulus decks), and two re-sorting effects (re-sorting

vs. no re-sorting). This research design is presented in Table 6.

Insert Table 6 about here

Classrooms at the first school were randomly assigned to sorting cue and re-sorting treatments. All subjects were randomly assigned to stimulus-presentation treatments. Four classrooms at the first school were sampled so that each cell would contain at least ten subjects. However, due to the nature of physical education scheduling, some classrooms did not have the expected thirty students. Therefore, students from one classroom at the second school were selected and randomly assigned to those cells with smaller numbers of subjects. Cell #12, which is identical to the standard procedure, was the control cell.

The implicit sorting cue treatment (ISC) received only task-orienting instructions--"sort those verbs together which you feel should be together." Subjects in the explicit sorting cue treatment (ESC) received the explicit sorting cue--"sort these verbs according to your views of facilitating learning in the classroom"--several times in different permutations in addition to the task-orienting instructions. All subjects were given general instructions concerning the physical nature of the task.

Subjects in the initial-homogeneous stimuli treatment (IHO) received stimulus decks in which the stimuli were randomized within their latent categories, which were also randomized (see Figure 1). Subjects in

Insert Figure 1 about here

Table 6

Experimental Design for the Study

		Initial-Homogeneous Stimuli	Initial-Heterogeneous Stimuli	Completely-Randomized Stimuli
Implicit Sorting Cue	No Re-sort	1	5	9
	Re-sort	2	6	10
Explicit Sorting Cue	No Re-sort	3	7	11
	Re-sort	4	8	12

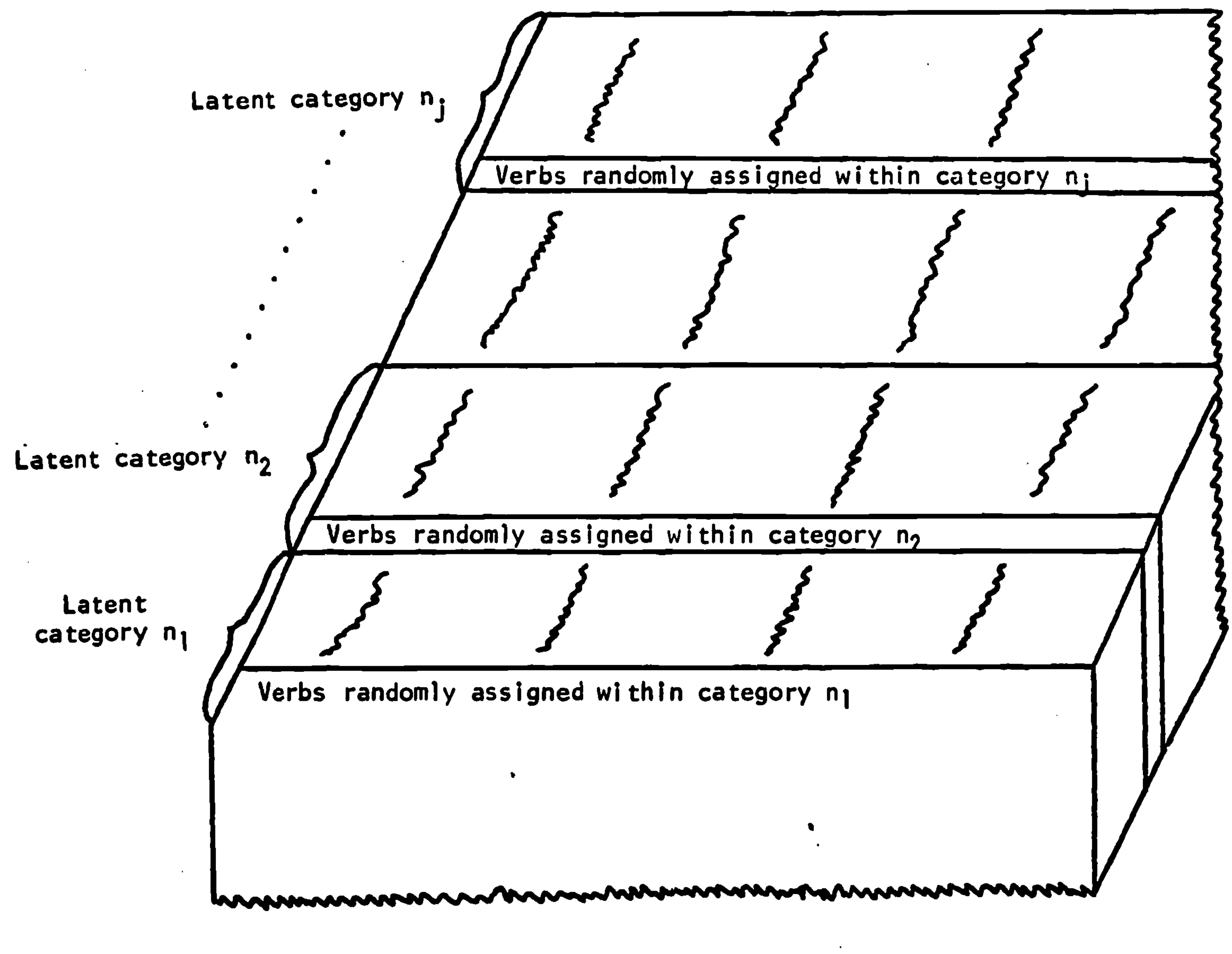

Figure 1. Randomization of the homogeneous (IHO) decks, where $n_1, n_2, \ldots, n_j$ are the randomly assigned numbers of each latent category.

the initial-heterogeneous stimuli treatment (IHE) received stimulus decks which presented the verbs with the highest probability within each latent category (keywords) first, followed by verbs of decreasing probabilities, with latent categories randomized (see Figure 2). Subjects in the

Insert Figure 2 about here

completely-randomized stimuli treatment (CRS) received stimulus decks in which all stimuli were completely randomized, regardless of the latent categories. This randomization and the punched stimulus cards were completed by computer procedures.

The re-sort (R) treatment was given instructions which strongly encouraged the sorter to re-sort his manifest categorizations. The no re-sort (NR) treatment had instructions which did not prevent stimulus re-sorting, but in no way encouraged such re-sorting. Rather, these subjects were encouraged to stay with their first categorizations.

Analysis

The results passed through a three-stage analysis. During stage one, LPA was utilized to obtain the underlying latent categorization of the total sample. Then, number of manifest categories, the Prototypic Discordance score and the Conceptual Disparity score were computed for each subject. These sorting behavior measures became the input for stage two, where Pearson product-moment correlations were computed among all variables.

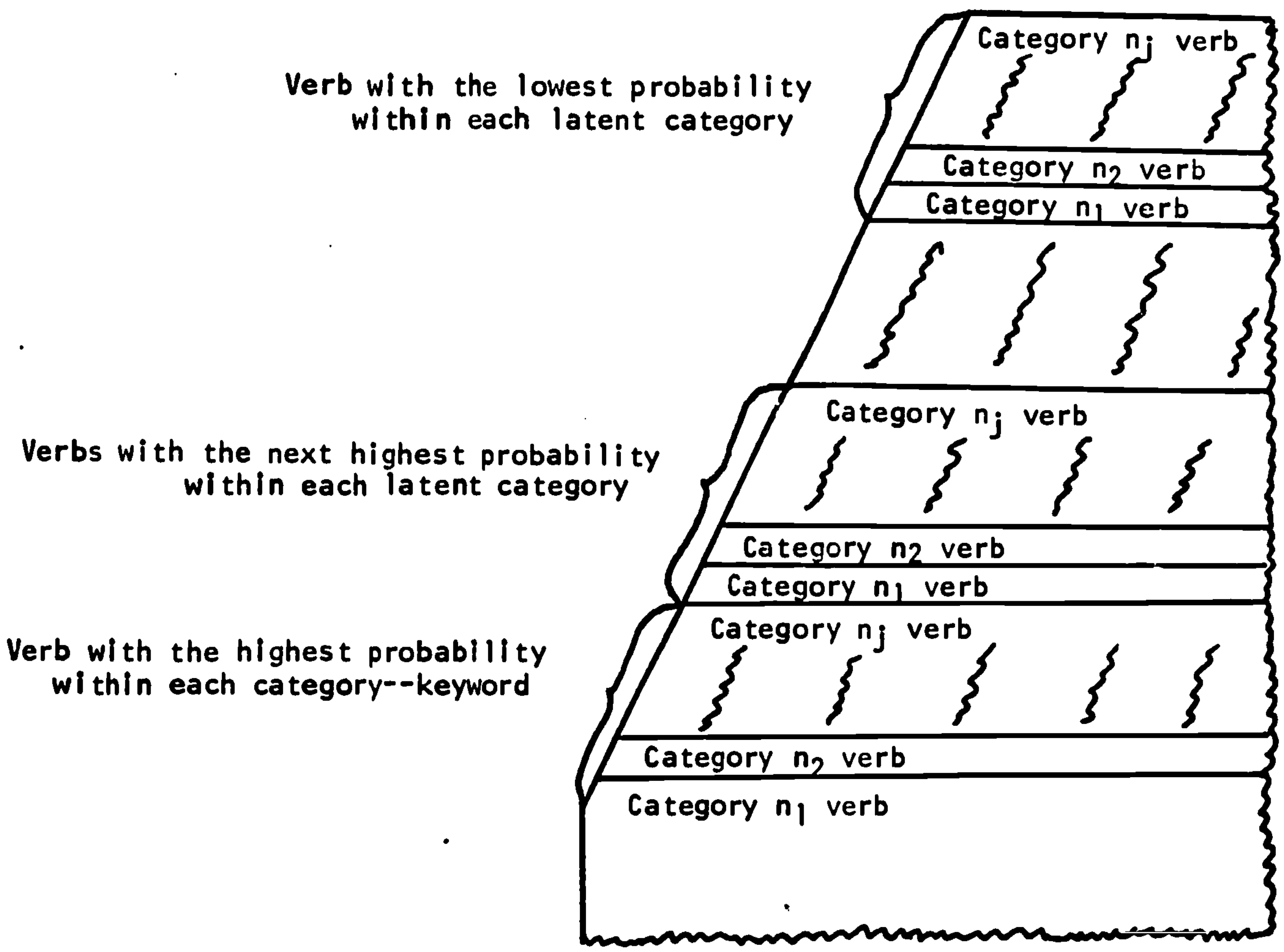

Figure 2. Randomization of the heterogeneous (IHE) decks, where $n_1, n_2, \ldots n_j$ are the randomly assigned numbers of each latent category.

The third stage was a multivariate analysis of covariance using the IBM 360/65 MESA98 Multivariate Analysis program with the three measures of sorting behavior as dependent variables and the age and performance measures as covariates. Each of the three treatment factors and their interactions were examined for post factum hypotheses to be tested at a later time.

RESULTS AND DISCUSSION

General Findings

The results of univariate analyses of the data by cell are presented in Table 7. The number of subjects per cell was either

Insert Table 7 about here

10 or 11 for all cells except cells 11 and 12, which had 9 and 12 subjects, respectively. The independent variables, age (in months) and ACT score (performance measure), differ little among the cells. Number of categories ranges from a mean of 5.33 for cell 12 to 9.91 for cell 1. Prototypic Discordance (PD) scores range from a mean of 85.77 for cell 4 to 151.98 for cell 11. Finally, Conceptual Disparity (CD) scores range from a mean of -20.74 for cell 11 to -2.22 for cell 6.

The results by treatment conditions (combinations of these cells) are much more readily interpretable. Table 8 shows that there is also little difference among treatments on the independent variables.

Insert Table 8 about here

TABLE 7

MEANS AND STANDARD DEVIATIONS (IN PARENTHESES) OF VARIABLES

BY CELL

STIMULI	INITIAL HOMOGENEOUS				INITIAL HETEROGENEOUS				COMPLETELY RANDOMIZED			
SORTING CUE	IMPLICIT		EXPLICIT		IMPLICIT		EXPLICIT		IMPLICIT		EXPLICIT	
RESORT	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
CELL NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
AGE (MONTHS)	215.73 (3.74)	214.20 (3.68)	218.30 (6.83)	217.54 (5.47)	216.36 (6.77)	216.20 (4.66)	219.10 (6.47)	217.09 (7.80)	217.40 (6.93)	217.90 (5.99)	215.22 (2.05)	217.25 (3.57)
PERFORMANCE MEASURE (ACT)	23.91 (3.70)	21.50 (4.84)	19.30 (5.89)	23.73 (2.65)	21.00 (5.83)	20.10 (5.26)	20.50 (5.82)	22.82 (5.90)	21.60 (4.12)	21.70 (5.03)	22.56 (7.54)	22.25 (6.21)
NUMBER OF CATEGORIES	9.91 (5.38)	8.00 (4.69)	6.50 (2.99)	7.00 (2.24)	6.36 (3.20)	7.60 (3.78)	5.80 (2.62)	6.09 (2.62)	9.60 (6.00)	6.40 (2.63)	5.33 (2.78)	5.75 (1.86)
PROTOTYPIC DISCORDANCE SCORE	93.65 (85.59)	115.42 (96.14)	106.10 (55.77)	85.77 (35.42)	117.37 (38.62)	99.38 (49.00)	125.11 (46.94)	101.45 (33.41)	106.22 (59.72)	126.01 (47.03)	151.98 (61.66)	112.61 (48.59)
CONCEPTUAL DISPARITY SCORE	- 3.68 (25.94)	-11.80 (26.02)	-1106 (14.65)	-12.94 (13.11)	-11.05 (12.28)	- 2.22 (13.60)	-10.80 (14.72)	- 7.88 (17.42)	- 3.55 (15.72)	-10.60 (13.18)	-20.74 (17.99)	-12.16 (18.13)
NUMBER OF SUBJECTS	11	10	10	11	11	10	10	11	10	10	9	12

TABLE 8

MEANS AND STANDARD DEVIATIONS (IN PARENTHESES) OF VARIABLES

BY TREATMENT

	INITIAL HOMOGENEOUS STIMULI	INITIAL HETEROGENEOUS STIMULI	COMPLETELY RANDOMIZED STIMULI	IMPLICIT SORTING CUE	EXPLICIT SORTING CUE	NO RESORTING	RESORTING	TOTAL GROUP
AGE (MONTHS)	216.45 (5.14)	217.17 (6.43)	217.00 (4.92)	216.29 (5.37)	217.44 (5.62)	217.02 (5.74)	216.73 (5.32)	216.87 (5.51)
PERFORMANCE MEASUREM (ACT)	22.19 (4.62)	21.14 (5.60)	22.02 (5.62)	21.66 (4.79)	21.90 (5.75)	21.49 (5.53)	22.06 (5.06)	21.78 (5.28)
NUMBER OF CATEGORIES	7.88 (4.10)	6.45 (3.05)	6.76 (3.87)	7.98 (4.48)	6.10 (2.47)	7.31 (4.32)	6.77 (3.05)	7.03 (3.72)
PROTOTYPIC DISCORDANCE	99.74 (68.78)	110.76 (41.99)	122.96 (54.81)	109.54 (63.27)	112.55 (49.70)	115.79 (60.34)	106.54 (52.93)	111.06 (56.63)
CONCEPTUAL DISPARITY	- 9.80 (20.39)	- 8.06 (14.54)	-11.56 (16.89)	- 7.16 (18.46)	-12.38 (15.93)	- 9.88 (17.73)	- 9.70 (17.15)	-9.79 (17.36)
NUMBER OF SUBJECTS	42	42	41	62	63	61	64	125

However, there do appear to be large differences on all three dependent variables on the presentation of stimuli and type of sorting cue treatments. The re-sort results do not appear to be substantially different.

The relationships between variables are explored in Table 9. Age and performance measures are correlated with each other but unrelated

Insert Table 9 about here

to the dependent variables. Indeed, in a regression analysis neither independent variable accounted for more than 1.3% of the variance on any given dependent variable. The multiple R squared values were only .088 for number of categories, .123 for Prototypic Discordance scores and .081 for Conceptual Disparity scores. Thus, neither of these independent variables accounted for very much variance in the model.

Number of categories relates positively to Conceptual Disparity score (e.g. the more manifest categories formed, the higher the CD score), but negatively to Prototypic Discordance score (e.g., the fewer manifest categories formed,the higher the PD score). Theoretically, CD scores should be uncorrelated with number of categories. But the number of latent categories is considerably higher than the average number of manifest categories (9 vs. 7.03). Thus, a large number of CD scores were negative indicative of this lower average number of manifest categories, which in turn led to the large positive correlation. Also, a low PD score indicates close correspondence to the average sort. The correlation between PD and number of categories closely approximates that

TABLE 9

INTERCORRELATIONS AMONG VARIABLES

	AGE	ACT	NCAT	PD	CD
AGE					
PERFORMANCE MEASURE (ACT)	-.190*				
NUMBER OF MANIFEST CATEGORIES (NCAT)	-.107	.025			
PROTOTYPIC DISCORDANCE SCORES (PD)	.099	-.083	-.702**		
CONCEPTUAL DISPARITY SCORES (CD)	.056	-.070	.726**	-.848**	

df = 123
*p<.05
**p<.01

found by Miller et al. (1967) in several of their sub-studies, except for the inverse relationship.

Hypothesis 1

It was hypothesized that there would be no difference between subjects receiving explicit or implicit sorting cues on the three dependent measures. However, the univariate tests of this hypothesis were significant for number of categories ($F=7.75$, $p<.006$) but not for Conceptual Disparity scores ($F=3.19$, $p<.076$) or Prototypic Discordance scores ($F<1$).

This highly significant result indicates that sorting cue had a potent influence upon the number of categories formed, but not on their type. This is especially significant since the most ambiguous stimuli were eliminated before sorting began, leaving a highly structured set of stimuli. Thus, the explicit sorting cue utilized appears to be more important than the inherent characteristics of the stimuli in forming the number of categories.

Hypothesis 2

It was hypothesized that the homogeneity of the initially-encountered stimuli would affect both the number and the type of manifest categorizations. Although the F-ratios for number of categories and Prototypic Discordance scores showed some effect, they were not statistically significant ($p<.185$ and $p<.199$, respectively). The F-ratio for Conceptual Disparity scores did not approach one.

These findings contradict the previous results (see Haenn, 1971). However, the ordering of means conformed to expectation. Subjects receiving homogeneous stimuli early in the sort tended to make more manifest

categories (mean=7.88) than subjects sorting initial-heterogeneous (mean=6.45) or completely randomized (mean=6.76) stimuli. This ordering of means was exactly as predicted, with the completely randomized stimuli mean closer to the mean for initial-heterogeneous stimuli. A Helmert contrast of the difference between initial homogeneous stimuli and the mean of the other two groups supports this contention, although the contrast was not significant ($F=3.30$, $p<.072$).

Both the initial-homogeneous and initial-heterogeneous means are lower than those reported in the previous study. However, this is due in a large part to the reduced number of stimuli (50 vs. 40 teacher verbs). Apparently, number of verbs sorted is an important factor influencing total number of categories formed. In fact, number of categories may even be age-related, since Miller's (1967) teacher-training seniors averaged only 6.3 categories before and 7.5 categories after a ten-week practice teaching period while experienced teachers (average age = 38.8 years) formed 10.0 categories. However, another, more important factor may be the amount of teaching experience.

Thus, although the trends do support this hypothesis, number and type of manifest categorizations do not appear to be significantly affected by order of stimulus presentation.

Hypothesis 3

It was hypothesized that re-sorting would affect the type, but not the number of final manifest categorizations. However, all F-ratios for this hypothesis are less than unity and only the latter condition appears to be true. These finding may be the result of the experimental

conditions themselves, since no subjects were prohibited from re-sorting. Only the Re-sort subjects were encouraged to re-sort their initial manifest categorizations.

However, the No Re-sort group took more time to complete their sorts (18.34 vs. 14.78 min.), suggesting that their initial categorizations were completed more cautiously or that they re-sorted as they proceeded. The results were re-analyzed, covarying sorting time. If the effect of sorting time is eliminated, Prototypic Discordance scores are significantly different ($F=4.22$, $p<.042$) as are Conceptual Disparity scores ($F=5.12$, $p<.026$) but number of manifest categories ($F<1$) is not significant. Thus, subjects encouraged to re-sort their manifest categorizations had significantly lower CD and PD scores, although this did not affect the number of categories formed. Thus, this hypothesis is supported.

Analysis of Interaction Effects

No interaction effects were hypothesized, but all were examined for post factum hypotheses. The only interaction effect to emerge was between sorting cue and re-sorting when sorting time is covaried. Number of manifest categories ($F=5.26$, $p<.024$) and Prototypic Discordance scores ($F=6.64$, $p<.011$) were both significant and Conceptual Disparity scores approached significance ($F=3.72$, $p<.056$). The estimated combined means showed that subjects receiving an explicit sorting cue but who were not encouraged to re-sort, formed fewer manifest categories and these categories were more highly discrepant as reflected by high PD and low CD scores.

SUMMARY

Three procedures of the free-sort methodology which are usually standardized were varied in an attempt to discover the effects of such variation upon the number and nature of manifest categorizations. The conditions investigated were effectiveness of the sorting cue, the effects of the order of stimulus presentation and the effect of re-sorting.

An explicit sorting cue was shown to be a highly significant determinant of the number of manifest categorizations, but not of the quality or nature of these categorizations when compared with an implicit (instructional) sorting cue. The effects of differing explicit sorting cues should be the object of further study.

The effects of stimulus ordering were not significant as anticipated, although the treatment means were in the predicted order. Subjects encountering initial stimuli which were very homogeneous formed more manifest categories (mean=7.88) than did subjects sorting decks with initial-heterogeneous (mean=6.45) or completely randomized (mean=6.76) stimuli.

Subjects encouraged to re-sort their manifest categorizations formed categories which were significantly different in nature, but not in number, from the categorizations of subjects who were not encouraged to re-sort. In addition, there was a significant interaction effect between re-sorting and type of sorting cue.

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